Betts & Bond

Experiments with Various Types of Gasoline Engines

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EXPERIMENTS WITH VARIOUS TYPES OF GASOLINE ENGINES

BY

DAVID ROY BETTS

AND

JOHN MYRON BOND

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

DAVID ROY BETTS and JOHN MYRON BOND

ENTITLED EXPERIMENTS WITH VARIOUS TYPES OF GASOLENE ENGINES

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering

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PRELIMINARY REMARKS.

As gasoline engines are becoming more and more important as prime movers and as data upon gasoline engine tests is very scarce, we decided to run the following tests and obtain as much data as possible.

All the tests given in this report were made by the writers on a Ten Horse Power Otto Gasoline Engine in the mechanical engineering laboratory of the University of Illinois. Two, tests beginning with a friction load, were run for each horse power to as high a load as the engine would carry.

It was our object to add some tests made on other machines but from lack of time we decided to work this data up carefully and have it reliable instead of more data but not so reliable.

PURPOSE OF TESTS.

These tests were made to obtain the following results:

(a) Cost, per brake horse power hour, for fuel, at different loads.

(b) Porportion of air to gasoline for different loads.

(c) Mechanical, thermal and potential efficiencies.

(d) Heat balance of the engine.

DESCRIPTION OF APPARATUS.

The Engine.

The engine used in all the following tests was an "Otto" ten horse power gasoline engine shown in photos, as installed in the mechanical engineering laboratory of the University of Illinois. This engine is rather old and at times considerable difficulty was experienced in making it run, due to water leaking into the cylinder. The oil used for lubrication outside of the cylinder was engine oil used for lubricating the engines in this laboratory. The oil used in the cylinder to lubricate the piston was a special gasoline engine oil with a high flash point.

Sparking Device.

The method of exploding the gas in the cylinder was by the electric spark made by several dry batteries and a vibrator connected to the poles of the machine.

Indicator.

The indicator used in all these tests was a Crosby gas engine indicator with a piston of 1-4 square inch area and a 120 pound spring was used. As the ordinary indicator piston has an area of 1-2 square inch, we will say that a 240 pound spring was used.

Fuel.

The gasoline used in all these tests was kept in a five gallon gasoline can on a box which rested on scales. The spout at the bottom of the can was right over the gasoline reservoir of the engine so that gasoline could be let into it without

moving the can. The scale on which the gasoline can and box rested was one on which we could weigh to hundredths of a pound, so the gasoline would be measured accurately. In a few tests a less accurate scale was used owing to the fact that this scale was in use for other work.

Brake.

The brake used to determine the brake horse power is shown in photos on pages 52 and 57.

A cast-iron water-cooled brake wheel 20 inches in diameter and 4 1-8 inches wide was made to bolt to the fly wheel to use in place of the driving pulley.

The brake shoes are of soft wood,(poplar in this case) backed by 1 inch maple pieces. The brake arm is built up of 3-4 inch pipe and fittings and is fastened to the brake-shoes by floor flanges. The lower shoe is connected rigidly to the brake arm, and the upper shoe is connected by means of a right and left nipple, which is a loose fit in both the tee and the floor flange so that it may be adjusted with the fingers. A bolt through the vertical pipe connects all rigidly when in place. The object of the right and left nipple is to allow for wear on the shoes and to permit the brake to be easily removed from the wheel.

The shoes are built up of material 1-2 and 1-4 inches thick, alternating:- The 1-2 inch strips form the bearing surface, the 1-4 inch strips being cut away for about 1-2 inch from the wheel. The strips are also slightly inclined across the face of the shoe, so that the bearing is not continuous across its width, but is a series of bands slightly slanted, the object of this being to insure smooth and even lubrication.

Air.

The air compressor shown in photo on page was used to compress the air in the high pressure air tank, shown in the same photo, to a pressure of about eighty pounds gage. This air was led through pipes to a low pressure tank which was kept at atmospheric pressure. The cubic capacity of the high pressure air tank is about ninety cubic feet and that of the low pressure air tank is about twelve cubic feet. The air was led from this low pressure tank to the intake of the engine by pipes in which there was two quick opening valves, one to let outside air into the pipe, the other to let the air from the tank into the engine.

Cooling Water.

The water from the jacket used to keep the cylinder cool was piped to a tank which rested on scales.

The water from the exhaust calorimeter, used in cooling the exhaust gases was also piped to a tank which rested on scales.

Exhaust Calorimeter.

The exhaust gases were conveyed through a pipe from the exhaust of the engine to a feed water heater fitted up to be used as a calorimeter to cool the exhaust gas to the temperature of the atmosphere. This calorimeter is shown in the photo on page 54. A feed water heater was used for this purpose and was covered on the outside with asbestos and mineral wool two inches thick, and the pipe connections were made as shown in photo and were covered with asbestos from the engine to the calorimeter. The method used is to send the exhaust gases through and around some tubes through which cold water is flowing. The cold water and gases never came together as there was always a thin tube between

them, but the heat would pass from the hot gases through the sheet of metal to the water. The water was then piped to the tank on scales and weighed and the exhaust gases were piped out of the building.

Manner of Conducting Tests.

The weights were all put on the safety valve of the compressor so that it would compress to a high pressure and all valves except the one in the pipe leading to the low pressure tank were closed. As soon as the compressor had run the pressure in the high pressure tank up to 75 or 80 pounds gage the valve leading to the compressor was closed and this air held till time to start the test. The engine was then started and the indicator passage opened once or twice to see that there was nothing caught in it and then the indicator was attached. The water was started running through the cylinder jacket and through the calorimeter. One man was stationed at the high pressure tank to read the pressure and temperature of the air when he blew the whistle for them to start the test. Another man was stationed at the indicator to take cards every two minutes when the whistle was blown and another man was stationed at the valve leading to the low pressure air tank and he watched the manometer in it and kept the pressure in the tank the same as that of the outside atmosphere. Another man was given a speed counter and stationed at the machine to take the revolutions per minute. Another man was stationed at the exhaust calorimeter to count the explosions because we found that the electric explosion counter would skip sometimes. Another man was stationed at the tanks on the scales to read the temperature of the entering and leaving waters and to weigh the amount from the

cylinder jacket and the exhaust calorimeter.

Starting Test.

When the test was started the man at the high pressure tank would give the signal and take the temperature and pressure in the high pressure air tank and then blow the whistle every two minutes and record similar data. The man at the indicator would take a card every time the whistle was blown. The man at the fly wheel would take the R. P. M. for one minute every time the whistle was blown and the man at the calorimeter would count the explosions every time he heard the whistle. The man at the weighing tanks would take the temperatures of the entering and leaving waters and at the first whistle he would put the pipes leading the water from the calorimeter and the cylinder into the tanks which were empty and had been weighed so that all water would be caught and weighed.

Stopping Test.

When the pressure in the storage tank got down pretty low the leader blew a signal to stop the test and read the pressure and temperature of this air. The man at the weighing tanks pulled the pipes out of the tanks, read the temperature and weighed the water in each tank. The air from the outside was then turned into the engine, the gasoline in the engine supply pipe brought up to the point of starting, the gasoline can weighed and the amount of gasoline used during the test was obtained. The gasoline supply to the engine was shut off and the engine stopped. The lubricating oil drips were also closed.

ENGINE DATA.

1. Name of Engine..........................Otto.
2. Manufactured by.........................Otto Gas Engine Works, Philadelphia, Pennsylvania.
3. Number of Cycles........................Four.
4. Kind of fuel used.......................Gasoline.
5. Heat of combustion......................#1, gasoline, 19,130 #2, gasoline, 19,263 B. t. u. per lb.
6. Rated horse power.......................10 H. P.
7. Floor space occupied....................4' 8" X 19' 1-2".
8. Number of cylinders.....................1.
9. Bore of cylinder........................5 3-4".
10. Stroke of piston.......................12 1-2".
11. Volume of cylinder.....................324 cu. in.
12. Clearance..............................107 cu. in.
13. Diameter of flywheels..................4'- 8".
14. Rated revolutions per minute...........300 R. P. M.
15. Kind of governor.......................Hit or miss.
16. Kind of ignition.......................Electric contact.
17. Kind of valves.........................Poppet.

EXPLANATION OF METHODS OF CALCULATING RESULTS.

Fuel:- The weight of the can of gasoline before and after each test was known and by subtracting we obtained the amount used. All tests before April 17, 1905 were run with the same gasoline which was analyzed by Prof. Parr of the chemistry department and an average of six analyses showed that the heating value of the fuel was 19,130 B.t.u. per pound. All tests on and after April 17, were run with a gasoline which was analyzed by Prof. Parr and an average of two analyses showed a heating value of 19,263 B.t.u. per pound.

In our calculations when it was desired to have the amount of gasoline per explosion the total amount of gasoline used during the test was divided by the number of minutes the test lasted and that result by the average number of explosions per minute during the test. When the volume of vapor of the gasoline was required, the weight in pounds was multiplied by 3.46 which gave the vapor volume in cubic feet.

Cooling water:- The weight of the tanks were known and after the test was stopped they were weighed and the difference gave the weight of water. The difference in temperature was also known and as it takes 1 B.t.u. to raise one pound of water from 59° to 60°F we multiplied the number of pounds of water by the number of degrees rise in temperature. As the temperatures were pretty close to 60°F we made no corrections for temperatures.

Air:- The method of calculating the air used was as follows:

$$P.\ V. = M.\ R.\ T.$$

$$\therefore\ M = \frac{P.\ V.}{R.\ T.}$$

Where P = Pressure in pounds per square foot.

" V = Volume of air in cubic feet.

" M = Mass of air in pounds.

" R = A constant, = 53.18.

" T = Absolute temperature

P and T are recorded for each reading, and V was determined by calibration to be 90.83 cubic feet. To find the amount of air used in any certain time, M for the beginning and end was figured and subtracting, we obtained the weight in pounds for that time. If it was desired to reduce this to cubic feet the pounds were multiplied by 13.4 as this is the volume of air per pound at 75°F and atmospheric pressure.

Brake Horse Power:- The brake horse power was figured from the formula;- $\frac{2\pi\ a\ W\ N}{33,000\ X\ 12} = B.\ H.\ P.$

Where a = length of brake arm = 62 1-2".

Where W = weight on brake scales in pounds.

Where N = number of revolutions per minute.

Indicated Horse Power:- The area of the card was found by means of a planimeter and the mean effective pressure was found by dividing this area by the length of the card and by multiplying by the strength of the spring = 240. The I. H. P. was then figured for each card by the formula;- $I.\ H.\ P. = \frac{P\ l\ a\ n}{33,000}$

Where P = mean effective pressure in pounds per square inch.

Where l = length of stroke in feet.

Where a = area of piston in square inches.

Where n = number of explosions per minute at time card was taken.

Mechanical Efficiency:-

$$\frac{\text{B. H. P.}}{\text{I. H. P.}} = \frac{\text{Brake Horse Power}}{\text{Indicated Horse Power}} = \text{Mechanical Efficiency.}$$

Thermo-dynamic Efficiency:- This efficiency was found by transferring one average card to the temperature volume plane by the method given in Reeve's Thermo-dynamics p 72-82, and dividing the area of the transferred card by the total heat area.

Potential Efficiency:- The potential efficiency =

$\frac{\text{The actual efficiency}}{\text{The ideal efficiency}}$ = the area of the transferred card divided by the area the card should have to be a perfect one theoretically.

Heat Balance:- The heat was used in the following ways:-

(1) Doing work.

(2) Heat lost to jacket water.

(3) Lost to exhaust.

(4) Lost to radiation.

(1) = I. H. P. X 33,000 X duration of test in minutes ÷ 778.

(2) = heat determined as lost to jacket cooling water.

(3) = heat obtained in the calorimeter water.

(4) = 100 - (1 + 2 + 3)

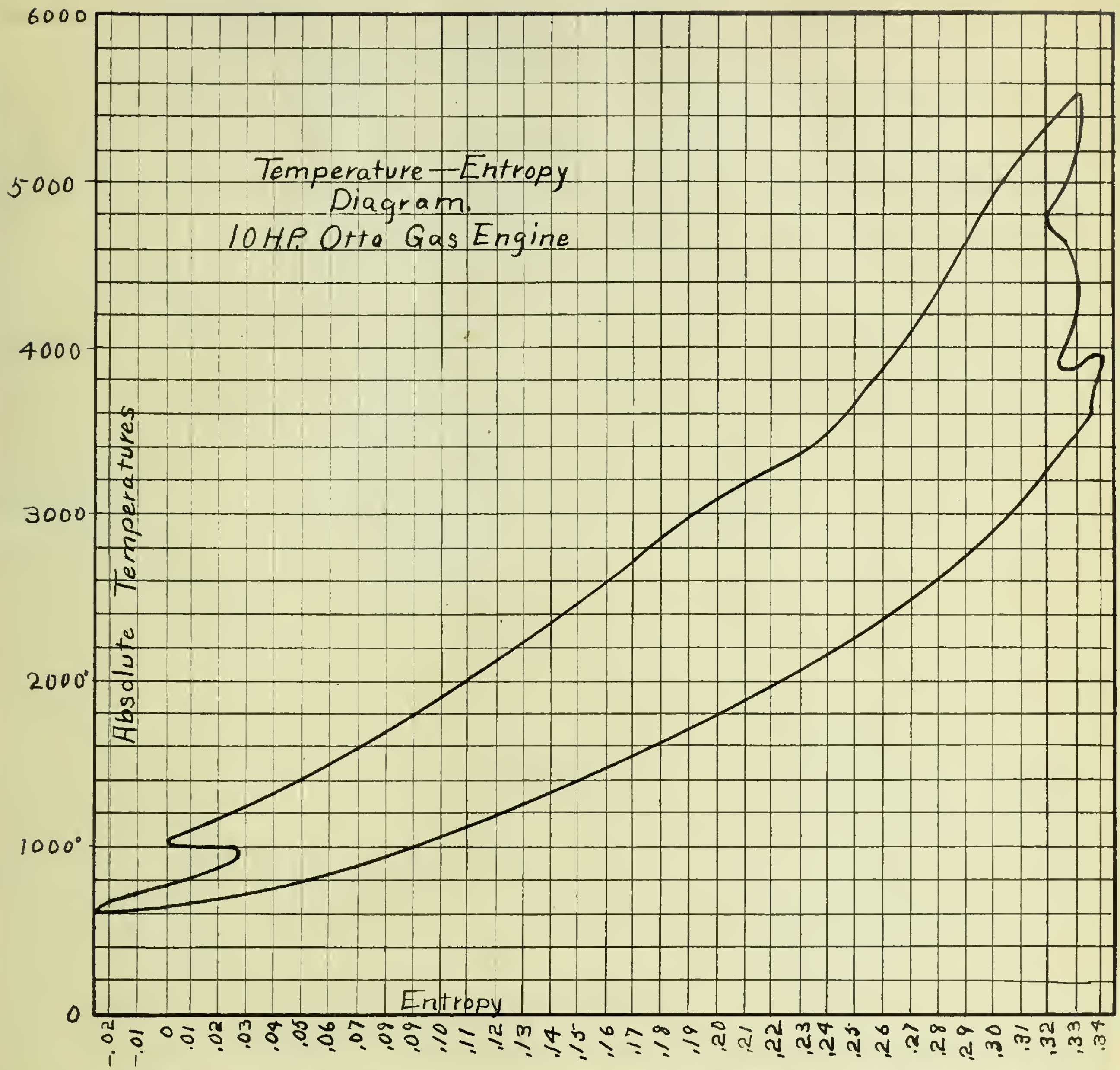
CONCLUSION.

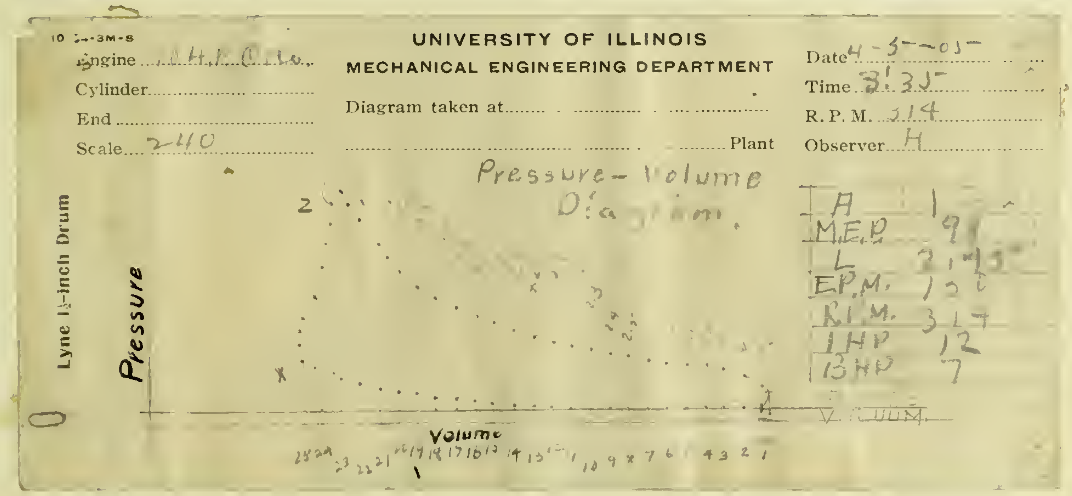
As a result of these tests we find that this engine works very well and requires very little attendance.

The most economical point of operation is at seven brake horse power. Ten brake horse power could not be obtained from the engine as the revolutions would immediately decrease when the brake load was raised above nine horse power.

An average card was taken and transferred from the P. V. plane to the T. N. plane and the thermodynamic efficiency found to be 34 per cent.

Enough data was not taken to determine the potential efficiency.


Temperature—Entropy
Diagram.
10 H.P. Otto Gas Engine
Absolute Temperatures
Entropy
6000
5000
4000
3000
2000°
1000°
0
-.02 -.01 0 .01 .02 .03 .04 .05 .06 .07 .08 .09 .10 .11 .12 .13 .14 .15 .16 .17 .18 .19 .20 .21 .22 .23 .24 .25 .26 .27 .28 .29 .30 .31 .32 .33 .34


UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT
Engine
Cylinder
End
Scale 240
Diagram taken at
Plant
Date 4-5-05
Time 3:35
R. P. M. 314
Observer H
Pressure-Volume
Diagram.
Lyne 1½-inch Drum
Pressure
Volume
M.E.P.
E.P.M.
R.P.M. 314
IHP 12
BHP 7

CALCULATIONS FOR TRANSLATING INDICATOR DIAGRAMS INTO TEMPERATURE–ENTROPY DIAGRAMS.

No.	$\frac{V_B}{V_X}$	$\frac{P_x}{P_B}$	$\frac{P_z}{P_B}$	$\log\frac{V_B}{V_X}$	$\log\frac{P_x}{P_B}$	$\log\frac{P_z}{P_B}$	T_x	T_z	N_x	N_z
1.	1.012	1.3	4	.006	.114	.602	614	2360	.047	.26
2.	1.048	1.5	5.5	.021	.176	.740	860	3140	.065	.313
3.	1.08	1.5	6.5	.033	.176	.813	835	3600	.056	.336
4.	1.12	1.5	7	.049	.176	.845	805	3740	.047	.342
5.	1.16	1.5	7	.064	.176	.845	775	3620	.038	.332
6.	1.2	1.5	7.5	.079	.176	.875	750	3700	.028	.336
7.	1.248	1.5	8	.097	.176	.903	720	3840	.017	.338
8.	1.297	1.5	8.5	.111	.176	.929	695	3940	.009	.34
9.	1.35	1.5	8.75	.1.30	.176	.942	665	3880	-.003	.334
10	1.4	1.5	9	.146	.176	.954	640	3840	-.013	.328
11.	1.472	1.5	9.5	.167	.176	.978	615	3880	-.026	.326
12.	1.543	1.75	10	.188	.243	1.00	680	3880	-.009	.324
13	1.62	2.	11	.210	.301	1.041	737	4050	.003	.328
14	1.71	2.	12	.233	.301	1.079	700	4200	-.012	.330
15	1.8	2.5	13	.255	.398	1.114	835	4320	.017	.332
16	1.91	2.9	13.5	.281	.462	1.130	910	4240	.029	.322
17	2.02	3	15	.305	.477	1.176	894	4350	.021	.328
18	2.16	3.5	17	.334	.544	1.230	970	4700	.032	.334
19	2.32	3.75	17.5	.365	.574	1.243	965	4550	.026	.320
20	2.49	4	20	.396	.602	1.301	960	4840	.099	.326
21	2.7	4.5	23	.431	.653	1.362	1000	5100	.019	.332
22	2.94	5	22.5	.468	.699	1.352	1020	4560	.017	.306
23	3.24	5.5	30	.511	.740	1.477	1035	5550	.009	.333
24	3.6	6	20	.556	.778	1.301	1000	3340	-.0009	.23
25	4.05	8	8	.607	.903	.903	1187	1187	.021	.021

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE — Friction Test — April 17, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO-DYNAMIC EFF.	POTENTIAL EFF.	B.T.U. PER # GAS	GAS PER MIN.	DATA FROM CARDS: AREA	LENGTH	M.E.P.	B.T.U. BALANCE: B.T.U. IN WORK	CYL. JACK.	IN EXH.	IN RAD.	REMARKS
P.M.				Cu. Ft.		cts.				Cu. Ft.	□"	"	#					
3:18	2.24	0		21.	56:1	15.			19263	.38	.97	2.45"	95.	2	7.5	3.8	47	
3:20	2.5	"		"	"	"			"	"	1.08	"	106.	"	"	"	"	
3:22	2.32	"		"	"	"			"	"	1.	"	98	"	"	"	"	
3:24	2.28	"		"	"	"			"	"	.95	2.45	93	"	"	"	"	
3:26	2.44	"		"	"	"			"	"	1.05	"	103	"	"	"	"	
3:28	2.44	"		"	"	"			"	"	1.05	"	103	"	"	"	"	
3:30	2.36	"		"	"	"			"	"	1.06	"	104	"	"	"	"	
3:32	2.46	"		"	"	"			"	"	1.1	"	108	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. Friction Test April 11, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS. PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO-DYNAMIC EFF.	POTENTIAL EFF.	B.T.U. PER # GAS.	DATA FROM CARDS AREA	LENGTH	M.E.P.	B.T.U. BALANCE B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu. Ft.	Cu. Ft.		cts.				□"	"	#					
3:22	1.92	0		21	.173	121:1	7.			19,130	1	2.45"	98	1.5	5.5	12.2	18.8	
3:24	2.06	"		"	"	"	"			"	1.05	2.45	98.05	"	"	"	"	
3:26	1.92	"		"	"	"	"			"	1.02	2.45	98.02	"	"	"	"	
3:28	1.76	"		"	"	"	"			"	.92	2.45	90.	"	"	"	"	
3:30	1.92	"		"	"	"	"			"	1.02	2.45	98.02	"	"	"	"	
3:32	1.98	"		"	"	"	"			"	1.	2.45	98.	"	"	"	"	
3:34	1.91	"		"	"	"	"			"	.96	2.45	94.	"	"	"	"	
3:36	1.91	"		"	"	"	"			"	.97	2.45	95.	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE — I.H.P. TEST — April 11, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO-DYNAMIC EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS AREA	DATA FROM CARDS LENGTH	DATA FROM CARDS M.E.P.	B.T.U. BALANCE B.T.U. IN WORK	B.T.U. BALANCE IN CYL. JACK.	B.T.U. BALANCE IN EXH.	B.T.U. BALANCE IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"						
3:00	3.1	1.	.32	19.8	.22	90:1	8.7	34		19,130	.83	2.45	81	2.4	3.2	1.65	1.575	
3:02	3.12	1.	.32	"	"	"	"	"		"	.82	"	80	"	"	"	"	
3:04	2.8	1.	.35	"	"	"	"	"		"	.75	"	73.	"	"	"	"	
3:06	3.28	1.	.305	"	"	"	"	"		"	.86	"	84.	"	"	"	"	
3:08	3.12	1.	.32	"	"	"	"	"		"	.82	"	80	"	"	"	"	
3:10	3.64	1.	.275	"	"	"	"	"		"	.95	"	93	"	"	"	"	
3:12	2.74	1.	.365	"	"	"	"	"		"	.68	"	66	"	"	"	"	
3:14	3.86	1.	.26	"	"	"	"	"		"	.9	"	88	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. I.H.P. Test. April 17, 1905.

											DATA FROM CARDS			B.T.U. BALANCE				
TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	AREA	LENGTH	M.E.P.	B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:52	3.82	1	.26	22	.26	85:1	10.4	34		19263	1.06	2.45	104	24	53	22	10.1	
2:54	3.96	"	.25	"	"	"	"	"		"	1.05	"	103	"	"	"	"	
2:56	3.3	"	.30	"	"	"	"	"		"	.9	"	88	"	"	"	"	
2:58	3.4	"	.294	"	"	"	"	"		"	.93	"	91	"	"	"	"	
3:00	4.12	"	.24	"	"	"	"	"		"	1.07	"	105	"	"	"	"	
3:02	3.46	"	.29	"	"	"	"	"		"	.9	"	88	"	"	"	"	
3:04	4.2	"	.24	"	"	"	"	"		"	1.15	"	113	"	"	"	"	
3:06	4.14	"	.24	"	"	"	"	"		"	1.1	"	108	"	"	"	"	
3:08	4.14	"	.24	"	"	"	"	"		"	1.1	"	108	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 2 H.P. TEST. April 11, 1905

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO GAS	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF	B.T.U. PER # GAS	DATA FROM CARDS: AREA	DATA FROM CARDS: LENGTH	DATA FROM CARDS: M.E.P.	B.T.U. BALANCE: B.T.U. IN WORK	B.T.U. BALANCE: IN CYL. JACKET	B.T.U. BALANCE: IN EXH.	B.T.U. BALANCE: IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:32	4.6	2	.43	2.05	.28	73:1	5.6	34		19,130	.85	2.45	83	2.8	22	3.7	13.3	
2:34	5.5	"	.36	"	"	"	"	"		"	1.01	"	99	"	"	"	"	
2:36	4.4	"	.45	"	"	"	"	"		"	.85	"	83	"	"	"	"	
2:38	4.65	"	.43	"	"	"	"	"		"	.91	"	89	"	"	"	"	
2:40	3.98	"	.50	"	"	"	"	"		"	.78	"	76	"	"	"	"	
2:42	4.9	"	.41	"	"	"	"	"		"	.9	"	88	"	"	"	"	
2:44	4.8	"	.42	"	"	"	"	"		"	.91	"	89	"	"	"	"	
2:46	5.17	"	.39	"	"	"	"	"		"	.98	"	96	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 2 H.P. Test. April 17, 1905.

TIME	I.H.P.	B.H.P.	B.H.P. / I.H.P.	AIR PER MIN.	GAS. PER MIN.	RATIO AIR TO GAS.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS: AREA	LENGTH	M.E.P.	B.T.U. BALANCE: B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts	%			□"	"	#					
2:30	4.8	2.	.415	22	.37	60:1	7.4	34		19263	1.11	2.45	109	3.1	5.9	2.5	3.1	
2:32	3.94	"	.507	"	"	"	"	"		"	.90	"	88	"	"	"	"	
2:34	4.6	"	.435	"	"	"	"	"		"	1.05	"	103	"	"	"	"	
2:36	4.25	"	.47	"	"	"	"	"		"	.97	"	95	"	"	"	"	
2:38	4.9	"	.41	"	"	"	"	"		"	1.11	"	109	"	"	"	"	
2:40	3.64	"	.56	"	"	"	"	"		"	.95	"	93	"	"	"	"	
2:42	3.7	"	.54	"	"	"	"	"		"	.94	"	92	"	"	"	"	
2:44	4.1	"	.49	"	"	"	"	"		"	.75	"	73	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 3 H.P. Test. April 17, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO G	COST PER B.H.P. HOUR	THERMO-EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS AREA	LENGTH	M.E.P.	B.T.U. BALANCE B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS.
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:05	7.7	3	.39	26	.27	96:1	3.6	34		19263	1.2	2.45	118	3.2	4.8	1.5	8.9	
2:07	6.75	"	.445	"	"	"	"	"		"	1.11	"	109	"	"	"	"	
2:09	6.6	"	.455	"	"	"	"	"		"	1.16	"	114	"	"	"	"	
2:11	6.7	"	.46	"	"	"	"	"		"	1.18	"	116	"	"	"	"	
2:13	6.1	"	.49	"	"	"	"	"		"	.98	"	96	"	"	"	"	
2:15	5.97	"	.50	"	"	"	"	"		"	.96	"	94	"	"	"	"	
2:17	5.7	"	.52	"	"	"	"	"		"	.92	"	90	"	"	"	"	
2:19	5.9	"	.51	"	"	"	"	"		"	.95	"	93	"	"	"	"	
2:21	5.3	"	.565	"	"	"	"	"		"	.88	"	86	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 3 H.P. Test. April 11, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO GAS.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS. AREA	LENGTH	M.E.P.	B.T.U. BALANCE. B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:09	6.05	3	.495	23.	.29	79:1	3.8	34		19,130	.95	2.45	93	3.2	4	24	7.9	
2:11	6.2	"	.485	"	"	"	"	"		"	1.	"	98	"	"	"	"	
2:13	4.65	"	.64	"	"	"	"	"		"	.75	"	73	"	"	"	"	
2:15	5.4	"	.55	"	"	"	"	"		"	.93	"	91	"	"	"	"	
2:17	5.55	"	.54	"	"	"	"	"		"	1.14	"	99	"	"	"	"	
2:19	5.25	"	.57	"	"	"	"	"		"	.88	"	86	"	"	"	"	
2:21	5.8	"	.52	"	"	"	"	"		"	1.18	"	99.2	"	"	"	"	

RESULT SHEET.

10 H.P. OTTO GASOLINE ENGINE. 4 H.P. Test. April 17, 1905.

TIME	I.H.P.	B.H.P.	B.H.P. / I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO GAS.	COST PER B.H.P. HOUR	THERMO DYNAMIC EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS: AREA	DATA FROM CARDS: LENGTH	DATA FROM CARDS: M.E.P.	B.T.U. BALANCE: B.T.U. IN WORK	B.T.U. BALANCE: IN CYL. JACKET	B.T.U. BALANCE: IN EXH.	B.T.U. BALANCE: IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
1:30	6.65	4	.60	26	.27	96:1	2.7	34		19263	1.	2.45	98	3.4	4.7	.57	6.33	
1:32	7.4	"	.54	"	"	"	"	"		"	1.1	"	108	"	"	"	"	
1:34	6	"	.666	"	"	"	"	"		"	.77	"	75	"	"	"	"	
1:36	7.85	"	.51	"	"	"	"	"		"	1.	"	98	"	"	"	"	
1:38	6.6	"	.60	"	"	"	"	"		"	.90	"	88	"	"	"	"	
1:40	8	"	.50	"	"	"	"	"		"	1.1	"	108	"	"	"	"	
1:42	6.25	"	.64	"	"	"	"	"		"	.86	"	84	"	"	"	"	
1:44	6.4	"	.625	"	"	"	"	"		"	.92	"	90	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE — 4 H.P. TEST — April, 11, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO GAS.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS: AREA	LENGTH	M.E.P.	B.T.U. BALANCE: B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
1:44	6.65	4	.60	21	.33	64:1	3.3	34		19,130	.80	2.45	78	3.1	2.4	5	6.5	
1:46	8.4	"	.475	"	"	"	"	"		"	1.	"	98	"	"	"	"	
1:48	5.78	"	.69	"	"	"	"	"		"	.70	"	68	"	"	"	"	
1:50	8.1	"	.49	"	"	"	"	"		"	1.	"	98	"	"	"	"	
1:52	8.2	"	.49	"	"	"	"	"		"	1.	"	98	"	"	"	"	
1:54	6.15	"	.65	"	"	"	"	"		"	.76	"	74	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 5 H.P. Test. April 6, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO-EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS AREA	LENGTH	M.E.P.	B.T.U. BALANCE B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS.
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
3:44	9.35	5	.535	22	.31	71:1	2.5	34		19,130	.84	2.45	82	3.15	7.8	1.3	4.75	
3:46	9.2	"	.544	"	"	"	"	"		"	.84	"	82	"	"	"	"	
3:48	9.7	"	.516	"	"	"	"	"		"	.89	"	87	"	"	"	"	
3:50	10.8	"	.47	"	"	"	"	.		"	1.01	"	99	"	"	"	"	
3:52	10.4	"	.473	"	"	"	"	.		"	1.00	"	98	"	"	"	"	
3:54	9.8	"	.51	"	"	"	"	"		"	.96	"	94	"	"	"	"	
3:56	9.8	"	.51	"	"	"	"	"		"	.97	"	95	"	"	"	"	
3:58	10.2	"	.476	"	"	"	"	"		"	1.02	"	100	"	"	"	"	
4:00	10.	"	.47	"	"	"	"	"		"	1.	"	98	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 5 H.P. Test. April 6, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMODYNAMIC EFF.	POTENTIAL EFF.	B.T.U. PER # GAS.	DATA FROM CARDS: AREA	DATA FROM CARDS: LENGTH	DATA FROM CARDS: M.E.P.	B.T.U. BALANCE: B.T.U. IN WORK	B.T.U. BALANCE: CYL. JACKET	B.T.U. BALANCE: IN EXH.	B.T.U. BALANCE: IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts	%			□"	"	#					
3:19	10.3	5	.475	20	.33	61:1	2.6	34		19,130	.99	2.45	97	32	8.7	14.4	.66	
3:21	9.15	"	.55	"	"	"	"	"		"	.90	"	88	"	"	"	"	
3:23	9.85	"	.51	"	"	"	"	"		"	.96	"	94	"	"	"	"	
3:25	9.5	"	.53	"	"	"	"	"		"	.94	"	92	"	"	"	"	
3:27	10	"	.47	"	"	"	"	"		"	1.	"	98	"	"	"	"	
3:29	9.8	"	.51	"	"	"	"	"		"	.97	"	95	"	"	"	"	
3:31	9.5	"	.53	"	"	"	"	"		"	.96	"	94	"	"	"	"	
3:33	9.7	"	.515	"	"	"	"	"		"	.97	"	95	"	"	"	"	
3:35	9.15	"	.55	"	"	"	"	"		"	.93	"	91	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 6 H.P. Test. April 6, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO GAS.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS AREA	LENGTH	M.E.P.	B.T.U. BALANCE B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:55	10.1	6	.594	22	.32	69:1	21	34		19,130	.91	2.45	89	3.3	3.	3.3	1.4	
2:57	10.1	"	.594	"	"	"	"	"		"	.88	"	86	"	"	"	"	
2:59	10.1	"	.594	"	"	"	"	"		"	.88	"	86	"	"	"	"	
3:01	10	"	.60	"	"	"	"	"		"	90	"	88	"	"	"	"	
3:03	9.8	"	.604	"	"	"	"	"		"	.85	"	83	"	"	"	"	
3:05	10.5	"	.57	"	"	"	"	"		"	.90	"	88	"	"	"	"	
3:07	10.1	"	.594	"	"	"	"	"		"	.86	"	84	"	"	"	"	
3:09	9.85	"	.605	"	"	"	"	"		"	.86	"	84	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 6 H.P. Test. April 6, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO GAS.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS AREA	LENGTH	M.E.P.	B.T.U. BALANCE. B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:30	10.7	6	.56	22	.35	62:1	2.4	34		19,130	90	2.45	88	3.27	9.7	6.5	.88	
2:32	10.8	"	.555	"	"	"	"	"		"	90	"	88	"	"	"	"	
2:34	9.9	"	.605	"	"	"	"	"		"	.84	"	82	"	"	"	"	
2:36	10.2	"	.59	"	"	"	"	"		"	.90	"	88	"	"	"	"	
2:38	7.3	"	.82	"	"	"	"	"		"	.66	"	64	"	"	"	"	
2:40	10.7	"	.56	"	"	"	"	"		"	.92	"	90	"	"	"	"	
2:42	10.6	"	.566	"	"	"	"	"		"	.91	"	89	"	"	"	"	
2:44	10.6	"	.566	"	"	"	"	"		"	.90	"	88	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 7 H.P. Test. April 5, 1905.

TIME	I.H.P.	B.H.P.	B.H.P. / I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO GAS.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS: AREA	DATA FROM CARDS: LENGTH	DATA FROM CARDS: M.E.P.	B.T.U. BALANCE: B.T.U. IN WORK	B.T.U. BALANCE: IN CYL. JACKET	B.T.U. BALANCE: IN EXH.	B.T.U. BALANCE: IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
3:43	11.4	7	.61	204	.34	60:1	1.92	34		19,130	.91	2.45	89	3.4	41	1.1	2.4	
3:45	9.	"	.78	"	"	"	"	"		"	.76	"	74.5	"	"	"	"	
3:47	11.12	"	.625	"	"	"	"	"		"	.90	"	88	"	"	"	"	
3:51	11.5	"	.61	"	"	"	"	"		"	.93	"	91	"	"	"	"	
3:53	10.8	"	.65	"	"	"	"	"		"	.86	"	84	"	"	"	"	
3:55	10.9	"	.64	"	"	"	"	"		"	.89	"	87	"	"	"	"	
3:57	10.5	"	.666	"	"	"	"	"		"	.82	"	80	"	"	"	"	
3:49	10.8	"	.65	"	"	"	"	"		"	.87	"	85	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 7 H.P. Test. April 5, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO GAS.	COST PER B.H.P. HOUR	THERMO-EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS AREA	LENGTH	M.E.P.	B.T.U. BALANCE B.T.U. IN WORK	IN JACKET	IN EXH.	IN RAD.	REMARKS.
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
3:19	11.9	7	.59	21.4	.4	53:1	2	34		19,130	.97	2.45	95	3.5	3.8	1.	.4	
3:21	12.1	"	.58	"	"	"	"	"		"	1.	"	98	"	"	"	"	
3:23	11.9	"	.59	"	"	"	"	"		"	.96	"	.94	"	"	"	"	
3:25	12.4	"	.56	"	"	"	"	"		"	1.02	"	101	"	"	"	"	
3:27	11.6	"	.60	"	"	"	"	"		"	.98	"	95	"	"	"	"	
3:29	11.8	"	.59	"	"	"	"	"		"	.97	"	95	"	"	"	"	
3:31	11.5	"	.61	"	"	"	"	"		"	.97	"	95	"	"	"	"	
3:33	12	"	.58	"	"	"	"	"		"	.99	"	97	"	"	"	"	
3:35	12	"	.58	"	"	"	"	"		"	1.	"	98	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE — 8 H.P. Test — April 5, 1905.

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO-EFF.	POT. EFF	B.T.U. PER # GAS	DATA FROM CARDS: AREA	DATA FROM CARDS: LENGTH	DATA FROM CARDS: M.E.P.	B.T.U. BALANCE: B.T.U. IN WORK	B.T.U. BALANCE: IN CYL. JACKET	B.T.U. BALANCE: IN EXH.	B.T.U. BALANCE: IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:25	12	8	.666	22.6	.58	39:1	3.	34		19,130	.97	2.45	95	3.8	4.7	1.4	81	
2:27	10.9	"	.73	"	"	"	"	"		"	.89	"	87	"	"	"	"	
2:29	10.7	"	.75	"	"	"	"	"		"	.86	"	84	"	"	"	"	
2:31	11.3	"	.71	"	"	"	"	"		"	.89	"	87	"	"	"	"	
2:33	10.7	"	.75	"	"	"	"	"		"	.88	"	.86.	"	"	"	"	
2:35	11.15	"	.72	"	"	"	"	"		"	.93	"	91	"	"	"	"	
2:37	10	"	.80	"	"	"	"	"		"	.87	"	85	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE — 8 H.P. TEST — April 5, 1905

											DATA FROM CARDS			B.T.U. BALANCE				
TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS, PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	AREA	LENGTH	M.E.P.	B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:55	13.3	8	.60	21	1.5	14:1	1.8	34		19,130	1.08	2.45	106	3.7	3.7	1.4	1.2	
3:00	11.37	"	.70	"	"	"	"	"		"	.95	"	93	"	"	"	"	
3:02	11.7	"	.68	"	"	"	"	"		"	.93	"	91	"	"	"	"	
3:05	10.95	"	.73	"	"	"	"	"		"	.92	"	90	"	"	"	"	
3:07	11.26	"	.71	"	"	"	"	"		"	.94	"	92	"	"	"	"	
3:09	11.3	"	.71	"	"	"	"	"		"	.94	"	92	"	"	"	"	

31.

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE. 9 H.P. Test. April 19, 1905

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS. PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO-EFF.	POTENTIAL EFF.	B.T.U. PER # GAS.	DATA FROM CARDS AREA	LENGTH	M.E.P.	B.T.U. BALANCE B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
1:56	9.6	9	.94	19.6	.46	43:1	2.2	34		19,263	.90	2.45	88	4.7	4.6	1.5	11	B.H.P./I.H.P. cannot be relied on as the en-
1:58	10.4	"	.88	"	"	"	"	"		"	.95	"	93	"	"	"	"	gine was not developing 9 H.P.
2:00	9.4	"	.96	"	"	"	"	"		"	.90	"	88	"	"	"	"	
2:02	8.3	"	1.08	"	"	"	"	"		"	.93	"	91	"	"	"	"	
2:04½	9.2	"	.98	"	"	"	"	"		"	.92	"	90	"	"	"	"	
2:06	9.1	"	.99	"	"	"	"	"		"	.94	"	92	"	"	"	"	
2:08	9.5	"	.95	"	"	"	"	"		"	1.	"	98	"	"	"	"	
2:10	7.9	"	1.21	"	"	"	"	"		"	.96	"	94	"	"	"	"	
2:12	7.	"	1.28	"	"	"	"	"		"	.90	"	88	"	"	"	"	

RESULT SHEET

10 H.P. OTTO GASOLINE ENGINE — 9 H.P. TEST — April 19, 1905

TIME	I.H.P.	B.H.P.	B.H.P./I.H.P.	AIR PER MIN.	GAS. PER MIN.	RATIO AIR TO G.	COST PER B.H.P. HOUR	THERMO. EFF.	POT. EFF.	B.T.U. PER # GAS.	DATA FROM CARDS: AREA	LENGTH	MEP.	B.T.U. BALANCE: B.T.U. IN WORK	IN CYL. JACKET	IN EXH.	IN RAD.	REMARKS.
P.M.				Cu.Ft.	Cu.Ft.		cts.	%			□"	"	#					
2:30	10	9	.90	18.1	.5	36:1	2.2	34		19,263	.90	2.45	88	4.5	4.4	1.1	9	The B.H.P./I.H.P. can
2:32½	9.7	"	.93	"	"	"	"	"		"	.90	"	88	"	"	"	"	not be used
2:34	9.35	"	.96	"	"	"	"	"		"	.90	"	88	"	"	"	"	as the engine
2:37	9.35	"	.96	"	"	"	"	"		"	.92	"	90	"	"	"	"	was not de-
2:39	9.3	"	.967	"	"	"	"	"		"	.91	"	89	"	"	"	"	veloping 9
2:41	9.9	"	.91	"	"	"	"	"		"	.95	"	93	"	"	"	"	H.P. at this
2:43	9.2	"	.97	"	"	"	"	"		"	.93	"	91	"	"	"	"	time.
2:45	9	"	1.00	"	"	"	"	"		"	.94	"	92	"	"	"	"	
2:47	8.55	"	1.05	"	"	"	"	"		"	.95	"	93	"	"	"	"	

DATA SHEET.

10 H.P. OTTO GASOLINE ENGINE. Friction TEst April 11, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS. # GAGE.	AIR TEMP. °F	TEMP. OF WATER. ENTERING	LEAVING CYL.	LEAVING CAL.	WT. OF WATER FROM CYL.	FROM CAL.	REMARKS.
P.M.						°F	°F	°F			
3:22	311	24	0#	61	104	64	160	95			Gasoline = .7#
3:24	312	26	"	53	98	"	158	96			
3:26	310	24	"	47	94	"	160	96			
3:28	311	24	"	40	90	"	158	94			
3:30	312	24	"	32	88	"	156	92			
3:32	311	25	"	25	86	"	152	90			
3:34	312	25	"	18	84	"	150	88			
3:36	312	24	"	12	82	"	150	88	17#	39#	

DATA SHEET.

10 H.P. OTTO GASOLINE ENGINE. Friction Test. April 17, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS #GAGE	AIR TEMP. °F	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.							°F	°F			
3:18	308	29	0	70	98	60°F	102	98			#2 Gasoline = 1.54#
3:20	309	29	"	60	92	"	101	99			
3:22	309	29	"	52	86	"	100	100			
3:24	311	30	"	44	81	"	99	100			
3:26	307	29	"	36	78	"	99	100			
3:28	304	29	"	28	76	"	99	100			
3:30	308	28	"	21	74	"	99	100			
3:32	309	28	"	18	74	"	98	100	78#	39#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. I.H.P. TEST April 11, 1905.

TIME.	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS. # GAGE	AIR TEMP. °F	TEMP. OF WATER. ENTERING	TEMP. OF WATER. LEAVING CYL.	TEMP. OF WATER. LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.							°F	°F			
3:00	310	47	$3\frac{1}{3}$#	60	94	66#	160	91			Gasoline=.88#
3:02	312	48	"	53	92	"	160	91			
3:04	312	47	"	46	90	"	162	91			
3:06	309	48	"	39	87	"	162	97			
3:08	310	48	"	31	84	"	165	97			
3:10	311	48	"	24	83	"	166	98			
3:12	311	51	"	17	82	"	168	94			
3:14	312	54	"	15	80	"	170	93	18.5#	34#	

36.

DATA SHEET.

10 H.P. OTTO GASOLINE ENGINE. 1 H.P. TEST. April 17, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS. # GAGE	AIR TEMP °F	TEMP. OF WATER			WT. OF WATER FROM		REMARKS.
						ENTERING	LEAVING CYL. °F	LEAVING CAL. °F	CYL.	CAL.	
P.M.											
2:52	310	45	$3\frac{1}{3}$#	72	100	59°F	116	96			Gasoline = 1.2#
2:54	310	47	"	61	94	"	116	97			
2:56	312	46	"	54	88	"	115	97			
2:58	311	46	"	46	84	"	114	98			
3:00	313	47	"	40	80	"	114	98			
3:02	311	48	"	32	78	"	113	98			
3:04	312	47	"	24	76	"	112	98			
3:06	312	47	"	18	74	"	111	98			
3:08	314	47	"	10	72	"	111	99	75#	42#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 2 H.P. TEST. April 11, 1905.

TIME.	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES #	AIR PRESS. GAGE	AIR TEMP. °F.	TEMP. OF WATER. ENTERING	TEMP. OF WATER. LEAVING CYL.	TEMP. OF WATER. LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.						°F	°F	°F			
2:32	310	67	$6\frac{2}{3}$#	62	98°F	64	120	90			Gasoline = 1.12#
2:34	312	68	"	56	94	"	122	90			
2:36	309	65	"	48	90	"	122	90			
2:38	311	64	"	39	86	"	122	90			
2:40	308	64	"	33	83	"	120	90			
2:42	312	68	"	25	84	"	156	90			
2:44	312	66	"	19	82	"	156	91			
2:46	311	66	"	15	80	"	160	90	21#	$93\frac{1}{2}$#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 2 H.P. TEST April 17, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS. # GAGE.	AIR TEMP. °F	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS
P.M.							°F	°F			
2:30	312	54	$6\frac{2}{3}$#	70#	96	59°F	112	93			#2 Gasoline = 1.5#
2:32	308	55	"	60	90	"	114	94			
2:34	311	55	"	52	86	"	115	94			
2:36	310	55	"	45	82	"	116	95			
2:38	312	55	"	38	78	"	118	95			
2:40	309	58	"	30	76	"	119	95			
2:42	311	59	"	23	74	"	120	96			
2:44	313	64	"	16	72	"	121	96	77#	51#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 3 H.P. TEST. April 11, 1905.

TIME.	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES #	AIR PRESS. GAGE.	AIR TEMP. °F	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.						°F	°F	°F			
2:09	309	80	10#	60	102	64	122	86			Gasoline = 1#
2:11	308	78	"	51	94	"	124	86			
2:13	312	78	"	44	91	"	126	86			
2:15	311	78	"	36	88	"	130	87			
2:17	310	79	"	29	86	"	132	88			
2:19	311	75	"	22	84	"	130	88			
2:21	313	72	"	15	82	"	132	88	57#	91.5#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 3 H.P. TEST April 17, 1905.

TIME.	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES #	AIR PRESS. GAGE.	AIR TEMP. °F	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL. °F	TEMP. OF WATER LEAVING CAL. °F	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M. 2:05	303	80	10#	71	84	58°	109	86			#2 Gasoline=1.26#
2:07	315	76	"	60	82	"	112	87			
2:09	312	71	"	54	80	"	115	88			
2:11	308	71	"	47	77	"	118	89			
2:13	319	78	"	40	76	"	121	90			
2:15	314	78	"	33	74	"	123	91			
2:17	312	77	"	25	72	"	124	91			
2:19	309	78	"	18	71	"	125	92			
2:21	313	76	"	11	70	"	126	92	86#	57#	

DATA SHEET.

10 H.P. OTTO GASOLINE ENGINE. 4 H.P. TEST. April 11, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS. # GAGE.	AIR TEMP. °F.	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL. °F	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.											
1:44	306	105	$13\frac{1}{3}$#	52	88	68°F	110	80			Gasoline = .96#
1:46	308	105	"	45	86	"	120	80			
1:48	309	104	"	38	84	"	122	80			
1:50	307	101	"	31	82	"	124	82			
1:52	309	103	"	24	82	"	128	82			
154	309	102	"	17	80	"	130	82	49#	67.75#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 4 H.P. TEST. April 17, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES #	AIR PRESS. GAGE.	AIR TEMP. °F.	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M. 1:30	303	83	$13\frac{1}{3}$ #	69	88	58 °F	107	78			Gasoline = 1.09 #
1:32	307	84	"	59	82	"	116	80			
1:34	311	98	"	52	78	"	123	80			
1:36	310	98	"	45	76	"	127	81			
1:38	296	98	"	39	74	"	131	81			
140	317	92	"	32	73	"	133	82			
1:42	309	91	"	24	72	"	134	83			
1:44	300	87	"	15	70	"	135	84	85 #	31 #	

DATA SHEET.

10 H.P. OTTO GASOLINE ENGINE. 5 H.P. TEST. April 6, 1905

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS # GAGE.	AIR TEMP. °F	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.						°F	°F	°F			
3:19	309	130	$16\frac{2}{3}$#	72#	100	60	119	90			Gasoline = 1.54#
3:21	308	128	"	63#	94	"	120	91			
3:23	315	128	"	56	88	"	126	94			
3:25	322	126	"	48.5	84	"	130	96			
3:27	311	125	"	40	80	"	135	97			
3:29	313	127	"	33.5	78	"	136	97			
3:31	311	124	"	26	74	"	138	97			
3:33	314	125	"	20	73	"	140	98			
3:35	312	125	"	16	72	"	140	99	235#	71#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 5 H.P. TEST. April 6, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES #	AIR PRESS. GAGE #	AIR TEMP. °F	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS
P.M.						°F	°F	°F			
3:44	314	140	$16\frac{2}{3}$#	71	100	61	120	100			Gasoline = 142#
3:46	313	137	"	63	92	"	125	101			
3:48	309	137	"	55	86	"	130	101			
3:50	315	134	"	48	82	"	132	96			
3:52	312	130	"	40	79	"	138	101			
3:54	305	128	"	33	76	"	140	103			
3:56	312	125	"	25	74	"	132	103			
3:58	312	126	"	18	72	"	140	104			
4:00	312	123	"	11	71	"	140	104	240#	66#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 6 H.P. TEST April 6, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS. # GAGE	AIR TEMP. °F	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.						°F	°F				
2:30	309	149	20#	62	82	60	150	71			Gasoline = 1.44#
2:32	314	151	"	54	80	"	150	72			
2:34	315	148	"	46	78	"	158	74			
2:36	312	142	"	40	76	"	155	75			
2:38	308	140	"	32	74	"	160	76			
2:40	313	146	"	25	73	"	166	78			
2:42	320	146	"	17	72	"	170	80			
2:44	318	148	"	11	70	"	170	81	190#	78#	

DATA SHEET.

10 H.P. OTTO GASOLINE ENGINE. 6 H.P. TEST April 6, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS # GAGE.	AIR TEMP °F	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS
P.M.						°F	°F				
2:55	311	140	20#	63	92	60	83	154			Gasoline = 1.3#
2:57	314	145	"	54	86	"	84	156			
2:59	309	140	"	47	82	"	86	160			
3:01	315	144	"	40	80	"	86	165			
3:03	312	146	"	32	78	"	88	160			
3:05	314	147	"	25	76	"	88	148			
307	311	148	"	18	74	"	90	144			
3:09	311	144	"	11	72	"	90	145	219#	78#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 7 H.P. TEST. April 5, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES #	AIR PRESS. GAGE	AIR TEMP. °F	TEMP. OF WATER ENTERING °F	TEMP. OF WATER LEAVING CYL. °F	TEMP. OF WATER LEAVING CAL. °F	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M. 3:19	312	154	$233\frac{1}{3}$#	66	104	61	152	104			Gasoline = 1.64#
3:21	313	152	"	56	98	"	160	106			
3:23	315	155	"	50	94	"	164	107			
3:25	313	151	"	43	89	"	165	109			
3:27	314	150	"	35	86	"	158	109			
3:29	313	153	"	26.5	84	"	150	109			
3:31	314	149	"	19	82	"	146	110			
3:33	314	153	"	13	80	"	145	110			
3:35	315	150	"	6	80	"	145	111	107#	48#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 7 H.P. TEST April 5, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS # GAGE	AIR TEMP. °F.	TEMP. OF WATER ENTERING	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.						°F	°F	°F			
3:43	312	157	233⅓#	65	108	62	144	112			Gasoline = 1.36#
3:45	313	150	"	58	102	"	146	112			
3:47	315	155	"	50	94	"	148	113			
3:49	313	156	"	43	92	"	149	114			
3:51	314	155	"	35	88	"	150	114			
3:53	313	158	"	27	84	"	150	115			
3:55	314	154	"	20	82	"	150	116			
3:57	314	156	"	13	80	"	150	116	102#	45#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE. 8 H.P. TEST April 5, 1905

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES #	AIR PRESS. GAGE #	AIR TEMP. °F	TEMP. OF WATER ENTERING °F	TEMP. OF WATER LEAVING CYL. °F	TEMP. OF WATER LEAVING CAL. °F	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS
P.M. 2:55	315	153	$26\frac{2}{3}$#	60	94	61	136	98			Gasoline = 1.55#
3:00	314	150	"	45	88	"	154	100			
3:02	316	157	"	37	85	"	164	101			
3:05	314	149	"	21	83	"	172	102			
3:07	314	150	"	18	81	"	176	102			
3:09	314	154	"	11	80	"	178	103	70#	73#	

DATA SHEET

10 H.P. OTTO GASOLINE ENGINE — 8 H.P. TEST — April 5, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES #	AIR PRESS. GAGE #	AIR TEMP. °F	TEMP. OF WATER ENTERING °F	TEMP. OF WATER LEAVING CYL. °F	TEMP. OF WATER LEAVING CAL. °F	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS
P.M.											
2:25	316	155	$26\frac{3}{3}$#	65	90	60°	136	90			Gasoline = 2.12#
2:27	314	154	"	57	88	"	144	91			
2:29	314	158	•	49	86	"	156	92			
2:31	313	153	"	43	84	"	162	94			
2:33	314	152	"	35	83	"	166	95			
2:35	315	150	"	26	80	"	170	96			
2:37	314	148	"	18	79	"	174	96	78#	73#	

DATA SHEET

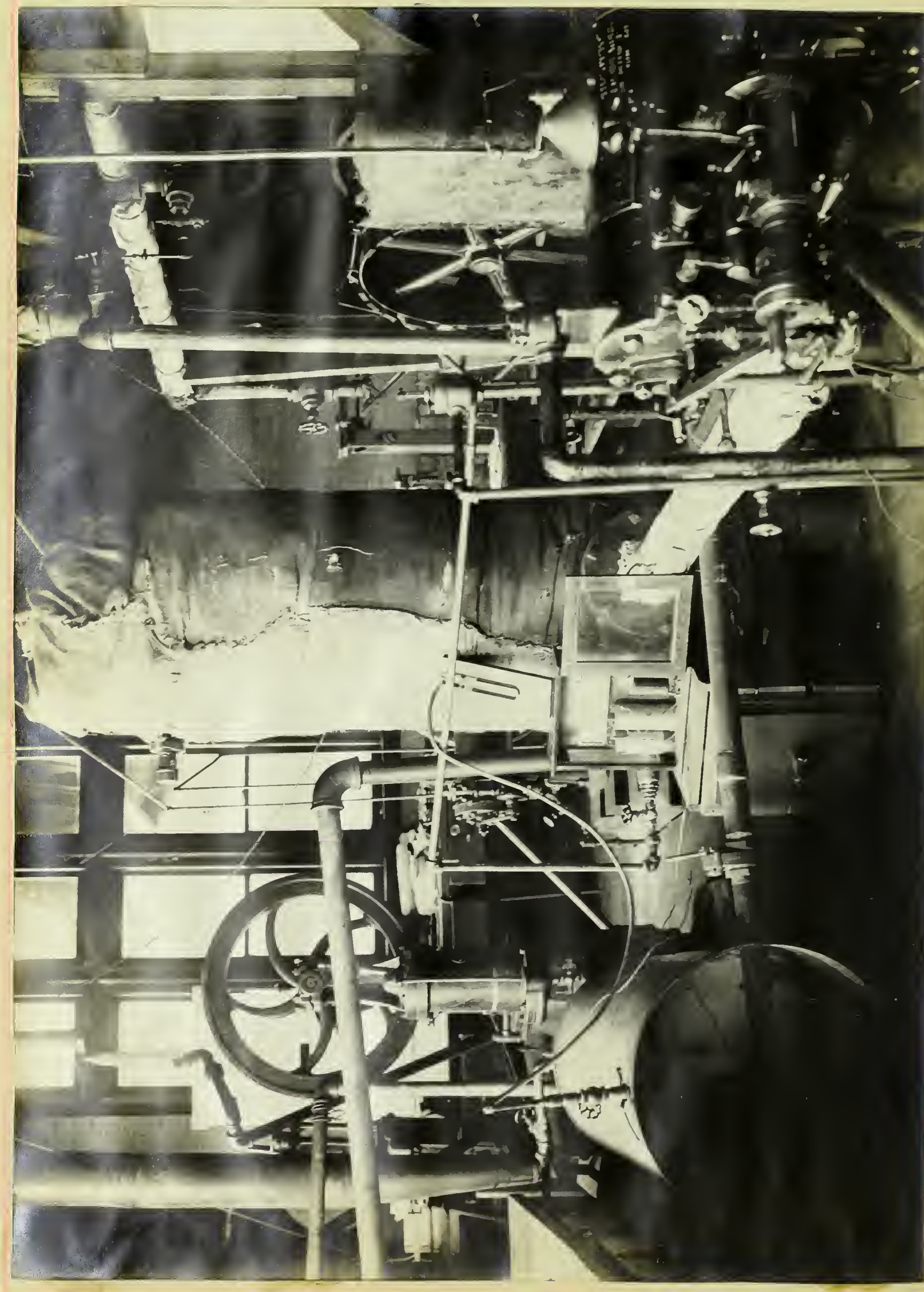
10 H.P. OTTO GASOLINE ENGINE — 9 H.P. TEST — April 19, 1905.

TIME P.M.	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS. # GAGE	AIR TEMP. °F	TEMP. OF WATER ENTERING °F	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL.	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
2:30	278	140	30#	71	90	64	152	101			Gasoline = 2.44#
2:32½	268	135	"	61	88	"	160	100			Exh. temp = 84°F
2:34	266	130	"	55	86	"	163	102			Atmos. temp = 86°F
2:37	251	127	"	47	83	"	158	102			
2:39	250	127	"	42	82	"	136	101			
2:41	243	130	"	36	79½	"	133	101			
2:43	243	124	"	30	79	"	139	100			
2:45	238	120	"	24	78	"	144	103			
2:47	220	113	"	18	78	"	148	102	115#	65#	

DATA SHEET.

10 H.P. OTTO GASOLINE ENGINE. 9 H.P. TEST. APRIL 19, 1905.

TIME	R.P.M.	E.P.M.	LOAD ON BRAKE SCALES	AIR PRESS. *GAGE.	AIR TEMP. °F.	TEMP. OF WATER ENTERING °F	TEMP. OF WATER LEAVING CYL.	TEMP. OF WATER LEAVING CAL. °F	WT. OF WATER FROM CYL.	WT. OF WATER FROM CAL.	REMARKS.
P.M.											
1:56	263	133	30#	60	90	64°	119	85			Gasoline used =
1:58	256	137	"	55	86	"	123	85			2.26#
2:00	248	131	"	49	84	"	126	86			Temp. of Exhaust
2:02	238	111	"	42	82	"	136	90			= 82°F
2:04½	236	125	"	36	80	"	138	91			Atmos. = 88½°F.
2:06	235	121	"	32	79	"	138	91			
2:08	230	119	"	26	78	"	137	92			
2:10	207	103	"	20	77	"	138	92			
2:12	188	97	"	15	76	"	139	97	118.5#	88#	



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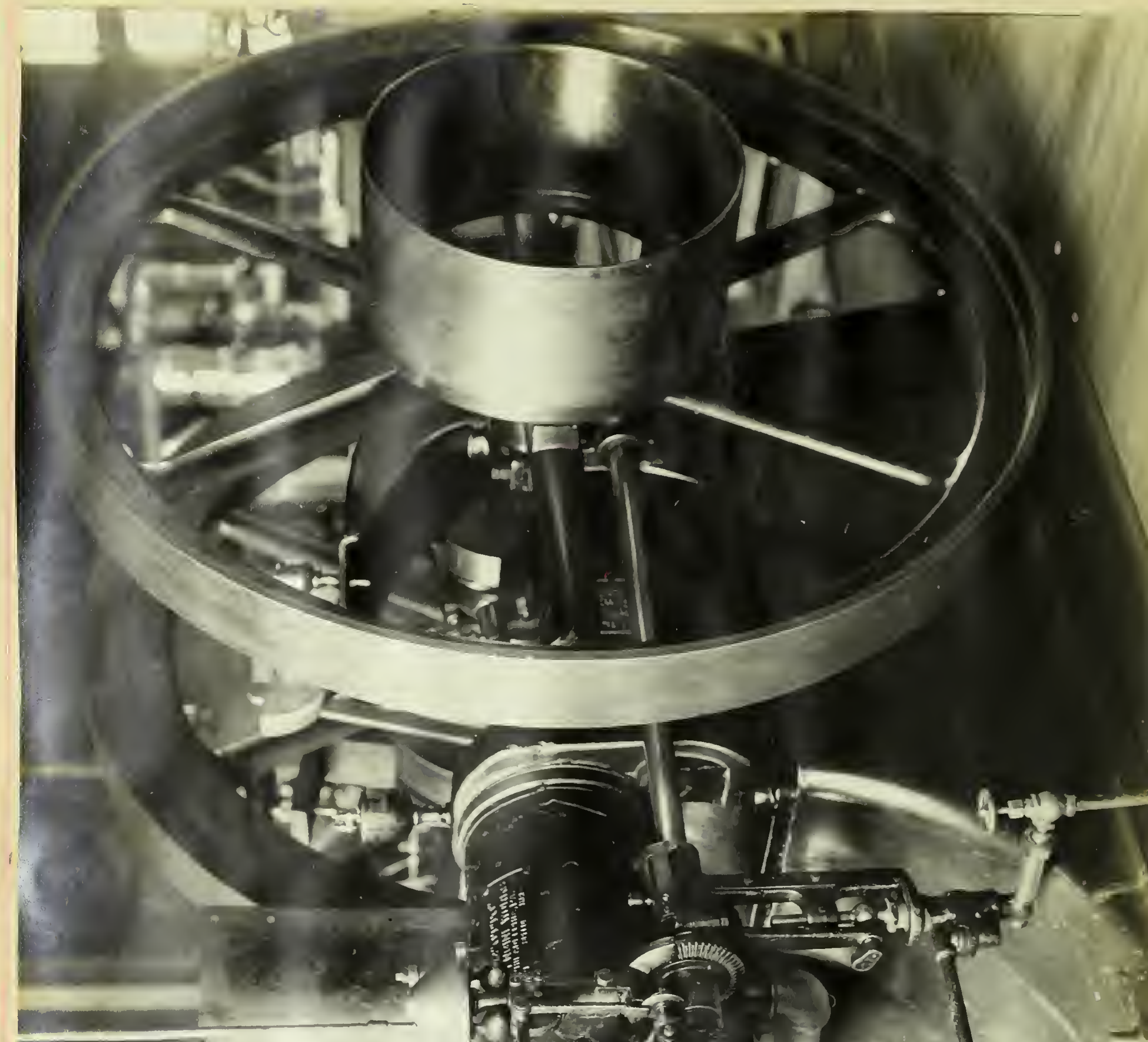


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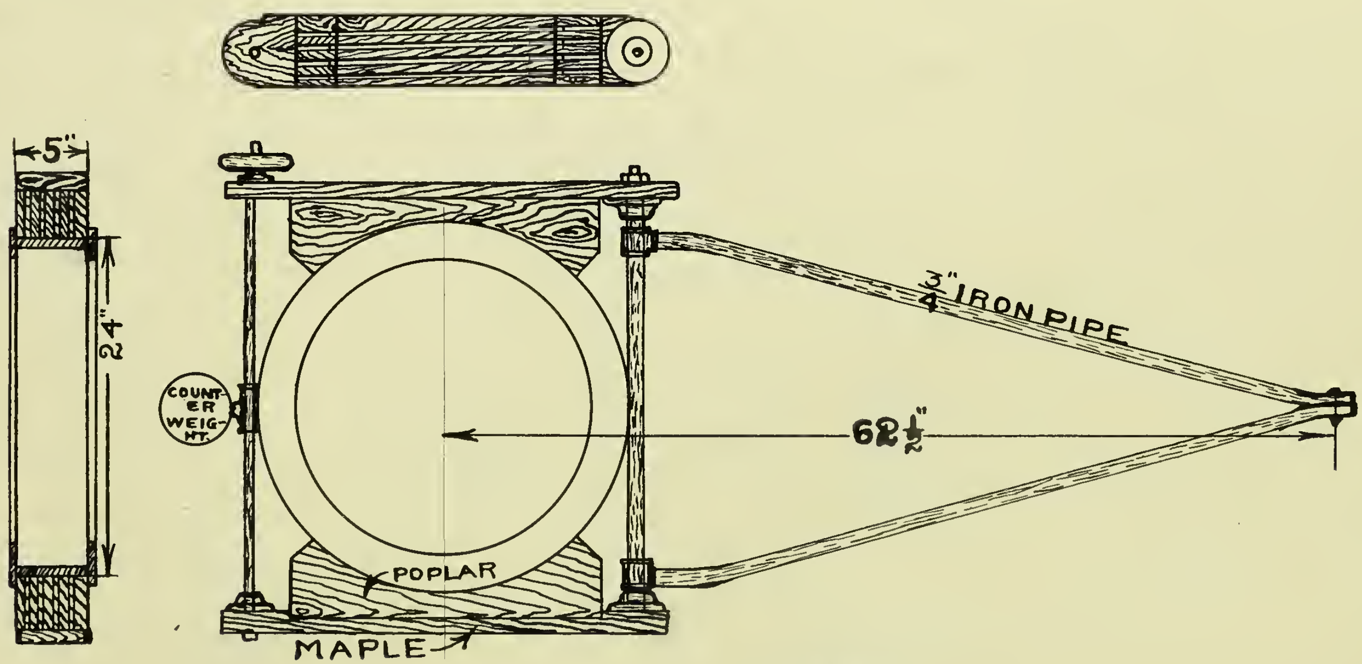

PRONY BRAKE.

Otto 10 H.P. Gasoline Engine.
Average cost per brake horse power hour
Gasoline at 15¢ per gal.